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A Review Paper of Microstrip Patch Antenna Design and its Application

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***Abstract*— Recent years have seen significant advancements in the study of microstrip patch antennas. Microstrip patch horns provide a number of benefits over standard microstrip patch, including the ability to be manufactured in large quantities, ease of integration with integrated microwave circuits (MICs), dual and triple functionality, cheap cost, low size, low weight, high performance, and low volume. This work examines the microstrip antenna design, analysis techniques for microstrip patch antennas, and their applications.**

***Keywords*— Microstrip patch antenna, Gain, Directivity, VSWR, Design, Biomedical Applications.**

I. Introduction

Microstrip patch antennas with broad bandwidth are necessary for biomedical applications. Although bandwidth in microstrip patch antennas is directly correlated with substrate thickness, it can also result in an increase in the antenna's overall volume. It has been shown that bandwidth may be increased for some biomedical applications of Microstrip Patch Antennas by employing the slotting approach.

On one side of the dielectric substrate and a plane underneath, a microstrip patch antenna (MPA) has a conductor (metal patch on a tiny, dielectric base) with any random or intended shape. For wireless microwave-band connections that need semi-hemispherical coverage, this printed resonant is used.

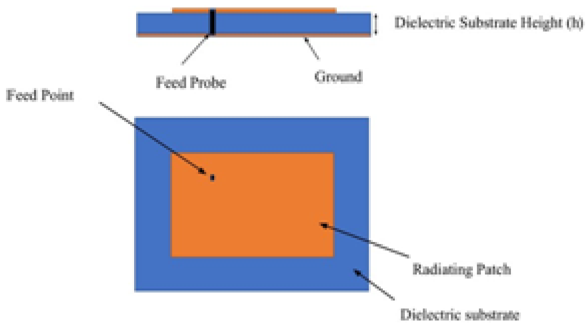

Figure 1. Geometry of Rectangular Microstrip Patch Antenna

Analysis Methods for Microstrip Patch Antenna

- Transmission Line Modeling
- Cavity model

Transmission Line Modelling

The first technique for analysing a rectangular microstrip antenna was this model. The size of the patch and the characteristics of the substrate dictate the limiting factor and the uniformity of the line dispersion. Although rectangular pieces were initially suggested for this model, further modification criteria were added.

Cavity Modelling

Lossy cavities are another name for microstrip patch antennas, which are narrowband resonant antennas. As a result, one option for analysing patch antennas is the cavity model. A cavity is created in the space between the patch and the ground plane. The field inside the cavity is consistent across the substrate's thickness since thin substrates are employed. It is possible to describe standard forms like

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triangles, circles, and rectangles in the fields beneath the patch.

Key Performance Parameters for Microstrip Patch Antenna

- Reflection Coefficient Bandwidth
- VSWR bandwidth
- Radiation pattern
- Surface Current
- Gain of antenna
- Input impedance
- Return Loss
- Polarization

Performance Enhancement Methods

- Slotting
- Defective Ground Structure
- Metamaterial

Frequently Used Substrate:

Dielectric Substrates: The substrate needs to get what you need for a certain application and satisfy specifications like thickness and bandwidth.

Table 1. Dielectric substrates and their characteristics

Substrates	Dielectric Constant	Loss Tangent
PTFE	2.1	0.0004
Polypropylene	2.18	0.0003
Teflon Dlass	2.55	0.0015
Roger 4350	3.48	0.004
RT-Duroid	2.2	0.0009

II. DESIGN OF MICROSTRIP PATCH ANTENNA

Four components make up the Microstrip Patch Antenna's single-layer design: the patch, ground plane, substrate, and feeding section. An antenna with a single element resonant can be categorised as a patch antenna. Everything (radiation pattern, input impedance, etc.) is fixed once the frequency is known.

The three important parameters for the design of a rectangular Microstrip Patch Antenna:

- Frequency of operation (fo)
- Dielectric constant of the substrate (εr)
- Height of dielectric substrate (h)

Using a substrate (FR4) with dielectric constant of (εr =4.4, h = 1.59 mm)

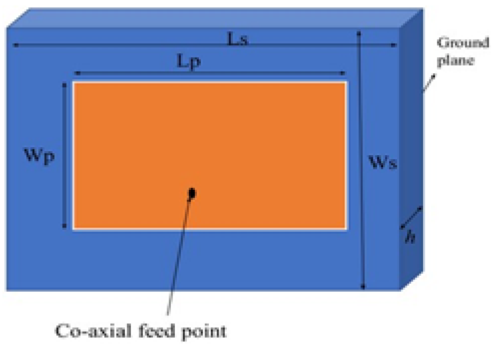

Figure 2: Geometry of Rectangular Patch Antenna
Feeding Methods

There are many methods of feeding a microstrip antenna. The most popular methods are:

1. Microstrip Line.
2. Coaxial Probe (coplanar feed).
3. Proximity Coupling.
4. Aperture Coupling

Microstrip Line Feed

Because it is so straightforward to build and to design and analyse, this feeding method is employed extensively. A patch

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with microstrip line feed from the side of the patch is seen in Figure (3).

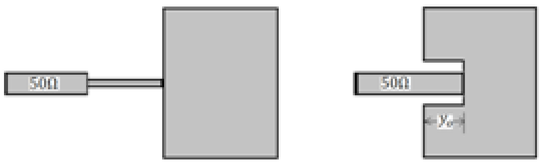

Figure 3: Microstrip Line Feed for Rectangular Patch

Coaxial Feed

Power to the patch antenna may be connected in a very easy, affordable, and efficient manner using a probe. The designer just has to utilise a 50Ω coaxial cable with an N-type coaxial connection if he changes the feed point to 50Ω.

As seen in the image, the N-coaxial connection is connected to the ground plane (back side) of the microstrip antenna, and the coaxial's centre connector is soldered to the patch after being passed through the substrate.

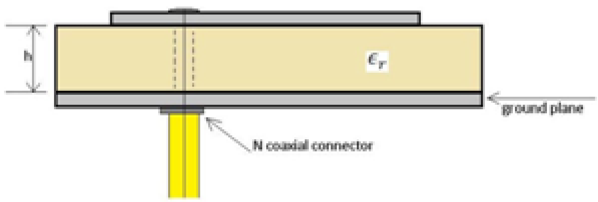

Figure 4. Coaxial Feed

Proximity coupling

Two substrates are used in proximity coupling: εr1 and εr2. As seen in the diagram, the patch will be on top, the ground plane will be at the bottom, and a microstrip line connecting to the power supply will be positioned in between the two substrates.

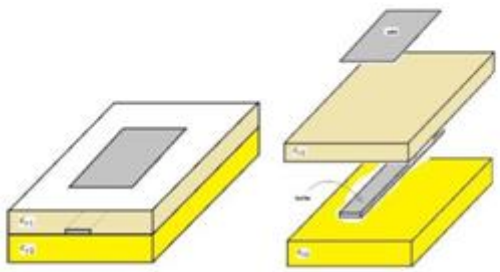

Figure 5. Proximity coupling

Aperture Coupling

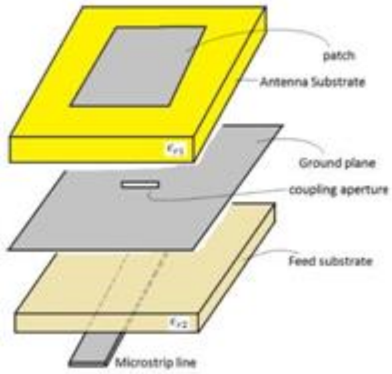

Figure 6. Aperture Coupling

The bottom substrate ℈ εr2, which has the microstrip feed line underneath it, and the higher substrate ℈ εr1, which has the patch on it, are separated by the ground plane's circular or rectangular aperture. There is a larger bandwidth with this kind of coupling.

III. Wireless PAN (Personal Antenna Network) in Medical Applications

In contrast to a wireless personal area network, the goal is to construct an RF hub with a patient who can recognise significant symptoms in patients, focus, and refer them to a base station across a short distance. WPANs can be used to establish wireless communication between the ECG nerves themselves as well as to connect to high-quality networks, the internet, and uplink (connection between persons).[11]

Conditions considered in the selection of most appropriate and efficient protocol in this area are:

- Data rate
- Distance
- Low battery power
- Safety and reliability
- Security
- Data Delay

An area of biomedical science that is widely used is the Bloodless System Pressure Rates investigation. The novel

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approach to measuring blood pressure is known as the arterial tonometer, which is a biomedical application of an antenna. The old, conventional method is known as the cuff method.

Cuff method

- It is accurate
- Continuous monitoring
- Discomfort due to stress
- Arterial tonometer
- It puts constant pressure on the artery in the wrist
- Constant pressure creates discomfort

Figure 7. Previous method used to check Blood Pressure

Figure 8. Arterial Tonometer investigation for Blood pressure

The durable design, extensive usage, and high performance of Microstrip patch antennas are widely recognised. The benefits of this Microstrip patch antenna outweigh its drawbacks, which include ease of construction and low weight.Applications may be found in a variety of industries, including satellites, medical applications, and, of course, military systems like missiles, aeroplanes, and rockets. Because of their cheap cost of manufacture and substrate material, microstrip antennas are becoming increasingly popular in many sectors and domains. They are also seeing a boom in the commercial sector. Additionally, it is anticipated that when patch antennas are used more often in extended range applications, they may eventually replace traditional antennas in terms of utilisation.

There are several uses for microstrip patch antennas in wireless communication. Circularly polarised radiation patterns are necessary for satellite communication, and square or circular patch microstrip antennas can be used to achieve this. Microstrip antennas that are circularly polarised are employed in global positioning satellite (GPS) systems. Because of where they are located, they are rather pricey despite their small size.

Moreover, mobile communication, RFID (radio frequency identification), and healthcare all make use of microstrip antennas. An RFID system basically consists of a reader and a tag. It typically employs frequencies in the range of 30 Hz to 5.8 GHz.

Microstrip antennas are used in telemedicine applications and run at 2.45 GHz. Wireless body area networks can benefit from the use of wearable microstrip antennas. Telemedicine applications can benefit from an antenna with a gain of 6.7 dB, a front-to-back ratio of 11.7 dB, and a resonant frequency of 2.45 GHz.

WiMax stands for "worldwide interoperability for microwave access," and it is a standard defined by IEEE 802.16. With a data throughput of 70 Mbps, it can cover a radius of up to 48 kilometres (30 miles). Multiple frequencies may be achieved resonance via microstrip antennas. As a result, WiMax-based communication devices can use them.

Microstrip patch antennae find application in radio altimeters, command and control systems, feed elements in complex antennae, satellite navigation receivers, mobile radio, integrated antennae, biomedical radiators and intruder alarms, Doppler and other radars, satellite communication, and direct broadcast services, among other communication-based fields.

IV. CONCLUSION

The design parameters of a rectangular microstrip patch antenna, including its resonating frequency, width, height, effective length, and applications, are examined. These drawbacks can be minimised while simultaneously balancing all three parameters by utilising a variety of microstrip antenna topologies, microstrip-based composite antenna formation, and advanced machining techniques for the microstrip antennas towards the highly integration of antennas for higher frequency. This paper presents an overview of microstrip antennas and their newest advances for a range of applications.

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